it is carried out will do much for biological research, viz. that steps be taken to establish and endow a central biological station at Port Jackson. Among the other reports may be mentioned one on the Polynesian races and Polynesian bibliography.

At the final meeting of the General Committee of the Association new special Committees were appointed to investigate and report on the following subjects: wheat rust, the manner of laying out towns, the preparation of geological maps, the arrangement of museums, the fertilization of the fig, Australian tides, and the present state of knowledge with regard to Australasian palæontology. A Committee was also appointed to formulate a scheme for obtaining practical assistance from the various Colonial Governments in the collection of material for research—chemical, geological, or biological. Other special Committees were appointed for the publication of the Transactions and for the revision of the laws of the Association.

The next meeting is to be held in Christchurch, New Zealand, probably in January 1891; and Sir James Hector has been elected President, and Prof. Hutton, Secretary. It has also been decided to hold the fourth meeting in Hobart, Tasmania, so that the Association will not again meet on the mainland for three years. To adventure so far as Christchurch is somewhat bold in so young an Association; but the success of the Melbourne meeting has demonstrated its usefulness and popularity, and warrants the belief that many will cross the water next year. There is even a strong hope felt by some that the occasion and the place may tempt a few of the members of the parent British Association to make the longer voyage from home, and see for themselves what is being done and what waits to be done for science at the antipodes.

ORME MASSON.

METEOROLOGICAL REPORT OF THE "CHALLENGER" EXPEDITION.[1]

PREVIOUS to 1872, discussions of the fundamental problems of meteorology relating to diurnal changes in atmospheric pressure, temperature, humidity, wind, and other phenomena, may be regarded as restricted to observations made on land. It had then, however, become evident that data from observations made on land only, which occupies about a fourth part of the earth's surface, were quite inadequate to a right conception and explanation of meteorological phenomena; and hence, when the *Challenger* Expedition was fitted out, arrangements were made for taking, during the cruise, hourly or two-hourly observations. These observations were published in detail in the "Narrative of the Cruise," Vol. II. pp. 305–74, and are still by far the most complete yet made on the meteorology of the ocean.

Elaborate observations were likewise made on deep-sea temperatures, which were at once recognized as leading to results of the first importance in terrestrial physics, and opening for discussion the broad question of oceanic circulation, on a sound basis of authentic facts. Preliminary, however, to any such inquiry, a full discussion of atmospheric phenomena was essential, requiring for its proper handling maps showing the mean temperature, mean pressure, and prevailing winds of the globe for each month of the year, with tables giving the data from which the maps are constructed. In other words, what was required was an exhaustive revision and ratification of Dove's isothermals, 1852; Buchan's isobars and prevailing winds, 1869; and Coffin's winds of the globe, 1875.

The work was entrusted to Mr. Buchan, of the Scottish Meteorological Society, in 1883, and was published in the beginning of this year. In addition to the tables of the appendices, giving the results of the *Challenger* observations, the more important are those giving the mean diurnal variation of atmospheric pressure at 147 stations in all parts of the world; the mean monthly and annual pressure at 1366 stations; a similar table of temperatures at 1620 stations; and the mean monthly and annual direction of the wind at 746 stations. It is believed that these tables include all the information at present existing that is required in the discussion of the broad questions raised in the Report, which includes, with the exception of the rainfall, all the important elements of the climates of the globe.

The Report itself is divided into two parts, the first dealing with diurnal, and the second with monthly, annual, and recurring phenomena. This is the first attempt yet made to deal with the diurnal phenomena of meteorology over the ocean—the temperature, pressure, and movements of the atmosphere, together with such phenomena as squalls, precipitation, lightning, and thunderstorms.

In equatorial and subtropical regions, the mean temperature of the surface of the sea falls to the daily minimum from 4 to 6 a.m., and rises to the maximum from 2 to 4 p.m., the amount of the diurnal variation being only 0°·9 F. In the higher latitudes of the Antarctic Ocean, the diurnal variation was only 0°·2. Of the four great oceans, the greatest variation was 1°·0 in the North Pacific, and the least 0°·8 in the Atlantic. This small daily variation of the temperature of the surface of the sea, shown by the *Challenger* observations, is an important contribution to physical science, being in fact one of the prime factors in meteorology, particularly in its bearings on the daily variations of atmospheric pressure and winds. The diurnal phases of the temperature of the air over the open sea occur at the same times as those of the temperature of the surface, but the amount of the variation is about 3°·0, and when near land the amount rises to 4°·4. The greater variation of the temperature of the air, as compared with that of the surface of the sea on which it rests, is a point of much interest from the important bearings of the subject on the relations of the air, and its aqueous vapour in its gaseous, liquid, and solid states, and the particles of dust everywhere present, to solar and terrestrial radiation. Thus the air rises daily to a higher and falls to a lower temperature than does the surface of the sea on which it rests.

The diurnal variation in the elastic force of vapour in the air is seen in its amplest form over the open sea, the results giving a curve closely coincident with the diurnal curve of temperature. But near land, the elastic force instead of rising towards, and to, the daily maximum at noon and 2 p.m., shows a well-marked depression at these hours, and indicates no longer merely a single, but a double maxima and minima. In other words, the curve now assumes the characteristics of this vapour curve as observed at all land stations, or where during the warmest hours of the day ascending currents rise from the earth's surface, and down-currents of drier air take their place. An important point specially to be noted here is that over the open sea, hygrometric observations disprove the existence of any ascending current from the surface of the sea during the hours when temperature is highest. On the other hand, the curve of relative humidity is simply inverse to that of the temperature, falling to the minimum at 2 p.m. and rising to the maximum early in the morning.

As regards the diurnal variation of the barometer, it is shown that the special forms of the monthly curves are, in their relations to the sun, direct and not cumulative as is the case with most of the monthly mean results of meteorology. The movement of the daily barometric oscillations from east to west is only quasi-tidal, being quite different from the manner in which the tides of the ocean are propagated from place to place over the earth's surface; these oscillations being, undoubtedly, directly generated by solar and terrestrial radiation in the regions where they occur, and it is thus only that the striking variations in the curves of restricted districts comparatively near each other are to be explained. These peculiarities do not occur over the open sea.

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[1] "Report of the Scientific Results of the Voyage of H.M.S. *Challenger* during the Years 1873–76." Prepared under the superintendence of John Murray, LL.D. "Physics and Chemistry," Vol. II., Part V. "Report on Atmospheric Circulation." By Alexander Buchan, M.A., LL.D.

As illustrating these variations, reference is made to the retardation of the time of occurrence of the morning maximum, which is delayed as the year advances, the latest retardation being in June; and the curves of 14 stations are given, these stations being situated in the middle and higher latitudes, and in localities which, while strongly insular in character, are at the same time not far from extensive tracts of land to eastward or south-eastward. These barometric curves for June present a graduated series, the two extremes being Culloden, where the morning maximum occurs at 7 a.m., and Sitka, where the same phase of pressure is delayed till 3 p.m., there being thus eight hours between them. Another set of curves is given from lower latitudes, showing the diurnal variation in mid-ocean from the *Challenger* observations, together with a series of land stations representing the influence of a land surface in increasing the amount of the variation, which reaches the maximum in the driest climates. Latitude for latitude, the maximum daily variation occurs in such arid climates as Jacobabad on the Indus, and the minimum over the anticyclonic regions of the great oceans. At Jacobabad the variation from the morning maximum to the afternoon minimum reaches 0·187 inch, whereas in the South Pacific it is 0·036 inch, and in the North Atlantic only 0·014 inch.

The following are some of the other types of barometric curves discussed—the curves at high-level stations on true peaks, and down the sides of the mountain; the curves in deep contracted valleys; those in high latitudes in the interior of continents where the morning minimum disappears; and those in high latitudes over the ocean where the afternoon minimum disappears. In the two last cases, the curve is reduced to a single maximum and minimum, which as regards the times of occurrence are the reverse of each other.

The atmosphere over the open sea rests on a floor or surface, subject to a diurnal range of temperature so small as to render that temperature practically constant both night and day; but notwithstanding this, the diurnal oscillations of the barometer occur over the open sea, equally as over the land surfaces of the globe. Hence the vitally important conclusion is drawn that the diurnal oscillations of the barometer are not caused by the heating and cooling of the earth's surface by solar and terrestrial radiation and by the effects following these diurnal changes in the temperature of the surface, but that they are primarily caused by the direct heating by solar radiation and cooling by terrestrial radiation of the molecules of the air and of its aqueous vapour, and the changes consequent on that cooling. It follows that these changes of temperature are instantly communicated through the whole atmosphere, from its lowermost stratum resting on the surface to the extreme limit of the atmosphere. There are important modifications of the barometric curves affecting the amplitude and times of occurrence of the principal phases of the phenomena, over land surfaces, for example, which are superheated during the day and cooled during the night according to the amount of aqueous vapour present in the atmosphere. But it is particularly insisted on that the barometric oscillations themselves are independent of any change in the temperature of the floor of the earth's surface on which the atmosphere rests. It scarcely requires to be added that these results of observation will necessitate the revision of all theories of the diurnal oscillations of the barometer that have assumed a diurnal change of the temperature of the surface on which the atmosphere rests as a necessary cause of these oscillations. The theory of the diurnal oscillations of the barometer submitted by Mr. Buchan may be thus stated: Assuming that aqueous vapour, in its purely gaseous state, is as diathermanous as the dry air of the atmosphere, it is considered that the *morning minimum* of pressure is due to a reduction of tension brought about by a comparatively sudden lowering of the temperature of the air itself by terrestrial radiation through all its height, and by a change of state of a portion of the aqueous vapour from the gaseous to the liquid state by its deposition on the dust particles of the air. The morning minimum is thus due, not to any removal of the mass of air overhead, but to a reduction of the tension by a lowering of the temperature and change of state of a portion of the aqueous vapour.

As the heating of the air proceeds with the ascent of the sun, evaporation takes place from the moist surfaces of the dust particles, and tension is increased by the simple change from the fluid to the gaseous state; and as the dust particles in the sun's rays rise in temperature above that of the air-films in contact with them, the temperature of the air is thereby increased, and with it the tension. Under these conditions the barometer steadily rises with the increasing tension to the *morning maximum;* and it is to be noted that the rise of the barometer is not occasioned by any accessions to the mass of air overhead, but only to increasing temperature of the air itself and change of state of a portion of its aqueous vapour.

By and by an ascending current of the warm air sets in, and pressure gradually falls as the mass of air overhead is reduced by the ascending current flowing back as an upper current to eastward—in other words, over the section of the atmosphere to eastward whose temperature has now fallen considerably lower than that of the region from which the ascending current is rising; and this continues till pressure falls to the *afternoon minimum.*

The back flow to eastward of the current, which has ascended from the longitudes where pressure at the time is at the minimum, increases pressure over the longitudes where temperature is now rapidly falling, and this atmospheric quasi-tidal movement brings about the *evening maximum* of pressure, which occurs from 9 p.m. to midnight according to latitude and geographical position. As the early hours of morning advance these contributions through the upper currents become less and less, and finally cease, and the effects of terrestrial radiation now going forward again introduce the morning minimum as already described. It is during the evening maximum that the diurnal maximum of periods of lightning without thunder and of the aurora take place, it being during this phase of the pressure that the atmospheric conditions result in an abundant increase of ice spicules in the upper regions of the atmosphere, which thus serve as a screen for the better presentation of any magneto-electric discharges that may occur.

It is interesting to note, in this connection, that the amount of the diurnal barometric tide falls conspicuously to the minimum, latitude for latitude, within the anticyclonic regions of the great oceans, where, owing to the descending currents which there prevail, deposition from the aqueous vapour is less abundant on the dust particles.

From a discussion of the whole of the two-hourly observations of the wind made during the cruise, sorted into those made over the open sea and those made near land, it is shown that the velocity of the wind is greater over the open sea than at or near land, the difference being from 4 to 5 miles per hour. The most important result is that there is practically no diurnal variation in the wind's velocity over the open sea. But as respects the winds observed near land, the velocity at the different hours of the day gives a curve as clearly and decidedly marked as that of the temperature, the minimum occurring from 2 to 4 a.m., and the maximum from noon to 4 p.m., the absolute maximum being at 2 p.m. The difference between the hour of least and that of greatest velocity is for the Southern Ocean 6½ miles; South Pacific, 4½ miles; South Atlantic, 3¼ miles; and North and South Atlantic, each 3 miles. It is also to be noted that even the maximum of the day near land in the case of none of the oceans attains to the velocity observed over the open sea. The curve near land is substantially the same as the curves characteristic of stations on land. Thus, over the sea, where surface temperature is practically a constant day and night, the velocity of the wind shows no diurnal variation; whereas over land, and also near it, where the temperature of the surface is subject to a diurnal variation, the wind's velocity is also subject to an equally well-marked diurnal variation. On the other hand, at high-level observatories situated on true peaks, the maximum velocity occurs during the night, and the minimum during the day. In deep valleys in mountainous regions, an abnormally high barometer obtains during the night, which is the result of cold currents from the adjoining slopes that the cooling effects of terrestrial radiation set in motion. Now since these down-flowing winds must be fed from higher levels than those of the mountain itself, the winds prevailing on their tops are really the winds of a higher level, and blow therefore with the increased velocity due to that greater height. On the other hand, during the warmer hours of the day, the barometric pressure in deep valleys is abnormally low, owing to the superheating of these valleys as contrasted with the temperature of the surrounding region, thus giving rise to a warm wind blowing up the valleys, and an ascending current close to the sides of the mountain up to the summit. Now, since no inconsiderable portion of this ascending current, whose horizontal velocity is necessarily much retarded, mingles with the air-current proper to the level of the peak, the wind on the peak is retarded, and falls to the minimum of the day when the temperature is highest.

The results of the averaging of the squalls over the open sea entered in the *Challenger's* log show a strongly marked diurnal maximum early in the morning, when the effects of terrestrial radiation are at the maximum. But over land the diurnal curves for whirlwinds, tornadoes, and allied phenomena, show the minimum at these hours, and the maximum at the hours when insolation is strongest. It is probable that the daily maximum occurs in each case at those hours when temperature decreases with height at a greatly more rapid rate than the normal.

The distribution during the day of thunderstorms, and of lightning without thunder, is very remarkable. During the cruise 26 thunderstorms occurred over the open sea, of which 22 occurred during the 10 hours from 10 p.m. to 8 a.m., and only 4 during the other 14 hours of the day. Hence, over the open sea, the diurnal curve of thunderstorms is precisely the reverse of what obtains on land. Of the 209 reported cases of lightning without thunder, 188 occurred during the 10 hours from 6 p.m. to 4 a.m., and only 21 during the other 14 hours of the day. The following are the hours of the maxima of these phenomena in the warmer months over land and the open sea respectively. Thunderstorms over land, 2 to 6 p.m.; lightning over land, 8 p.m. to midnight; lightning over the open sea, 8 p.m. to 4 a.m.; and thunderstorms over the open sea, 10 p.m. to 8 a.m. These facts are a valuable contribution to the science, from their intimate connection with the ascending and descending currents of the atmosphere.

The second part of the Report, dealing with the monthly and annual phenomena, aims at giving a comparative view of the climatologies of the globe to a degree of completeness not previously attempted. The distribution of the temperature and pressure of the atmosphere and prevailing winds is illustrated by 52 newly constructed maps, of which 26 show by isothermals the mean monthly and annual temperature on hypsobathymetric maps, first on Gall's projection, and second on north circumpolar maps on equal surface projection; and 26 show, by isobars, for each month and for the year, the mean pressure of the atmosphere, with the gravity correction to lat. 45° applied, and by arrows the prevailing winds of the globe. Two other maps are given in the text, one showing for July the geographical distribution of the amount of the barometric oscillation from the morning maximum to the afternoon minimum; and the other, the annual range of the mean monthly pressure, which, in a sense, may be regarded as indicating the relative stability of the atmospheric pressure in different regions of the earth.

For the details of this discussion, we must refer to the Report itself, the broad results of which Mr. Buchan thus summarizes:—

"The isobaric maps show, in the clearest and most conclusive manner, that the distribution of the pressure of the earth's atmosphere is determined by the geographical distribution of land and water in their relations to the varying heat of the sun through the months of the year; and since the relative pressure determines the direction and force of the prevailing winds, and these in their turn the temperature, moisture, rainfall, and in a very great degree the surface currents of the ocean, it is evident that there is here a principle applicable not merely to the present state of the earth, but also to different distributions of land and water in past times. In truth, it is only by the aid of this principle that any rational attempt, based on causes having a purely terrestrial origin, can be made in explanation of those glacial and warm geological epochs through which the climates of Great Britain and other countries have passed. Hence the geologist must familiarize himself with the nature of those climatic changes which necessarily result from different distributions of land and water, especially those changes which influence most powerfully the life of the globe."

It is evident from what has been said that many of the results of the diurnal and seasonal phenomena of ocean meteorology are equally novel and important, and, when combined with the analogous results obtained from land observations, enable us to take a more intelligent and comprehensive grasp of atmospheric phenomena in their relations to the terraqueous globe taken as a whole than has hitherto been possible.

THE BOTANICAL LABORATORY IN THE ROYAL GARDENS, PERADENIYA, CEYLON.

THE attention of the readers of NATURE has been drawn more than once (vol. xxxi. p. 460, vol. xxxiv. p. 127) to the opportunities which are before botanists for the study of plants other than those of our own flora. But since the latter of these articles appeared, a step has been taken which will justify a return once more to this important subject.

It is certainly one of the most healthy signs of the present time that our younger botanists desire not merely to pore over minute details of microscopical structure in the laboratory at home, but to become personally acquainted with plants in the open. When the somewhat sudden reversion occurred some fifteen years ago, from taxonomy as an academic study, to the more detailed examination of the tissues of plants in the laboratory, and the study of their functions, those who took a large view of the progress of the science must have seen with regret that the change, however valuable in itself, brought with it a new danger. Those who as students were first introduced to plants as subjects of microscopic study ran